

## APOLLO 16 MEED MYCOLOGY

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**Abstract:** Apollo 16 housed selected fungal species that were exposed to specific spaceflight parameters. Chaetomium globosum, Trichophyton terrestre, Rhodotorula rubra, and Saccharomyces cerevisiae were included for studies in exomycology. Postflight studies continue on the 1972 Apollo lunar flight to evaluate changes incurred in space in the selected fungal species. The Microbial Ecology Evaluation Device (MEED) spaceflight hardware was designed to allow for a quantitative and qualitative study of specific spaceflight parameters using selected species as the test systems.

**Introduction:** The MEED project of Apollo 16 was a cooperative study involving the expertise, time and efforts of many individuals representing many disciplines. A decidedly strong team effort was required and that strength was reflected in the desire and interest of each team member to make the project successful. Preflight investigations can predict probable occurrences in space when the fungal species are exposed to the environmental parameters of space. The collection and analysis of postflight data determines in fact what actually did occur in space and the changes resulting from the stresses received by the fungal species. The slow process of experimentation and interpretation of retrieved fungal cells from space gradually accumulates data that indicates what changes did occur to the cells. Analysis of postflight data, examination of the exposed cells, and continued studies on progeny of the space flown species gradually accumulates the information on the effects of space on individual living cells and living cellular systems. If the structure is a unicellular microscopic organism or a complex animal or plant composed of numerous tissue types, the spaceflight information gained from a single cell or tissue may be related to humans subjected to space travel. Medically related information can be gained from nonmedical studies and from nonpathogenic microorganisms. Preflight studies, flight preparations and launch procedures of the MEED studies were housed in the Preventive Medicine Division of NASA Manned Spacecraft Center, Houston, Texas.

A complex coordination of many individuals, countless specialized disciplines, a wide array of design and experimentation covering a time segment clocked in years will finally realize a completed space study. Each individual is important in the coordinated effort. From engineer to mycologist, from statistician to illustrator, each discipline adds interpretation and assistance to the accumulation of information recording changes incurred in space on the fungal cells exposed to specific measurable test parameters found in the somewhat hostile environment of space. The hostility

fades when adequate protection is given living forms, yet microscopic organisms can survive prolonged exposures to space environment with a minimum amount of protection from space irradiations. They can also survive the removal of a gaseous atmosphere found as the protective cover on earth.

Preflight studies for identifying the suitability of a fungal species for the planned exomycology study produces necessary information for fungi returned from space. A bioengineer designs an experimental package that will become spaceflight hardware. Fabrication experts decide upon specific materials that will become required components for the basic hardware package suitable for the fungal study. The materials are tested for reliability and safety requirements. An expert in ultraviolet light irradiations makes suggestions on specific light wavelengths and energy levels best to incorporate in the study. A textile company develops new materials suitable for space travel that form a stowage bag for the flight hardware on board the command module spacecraft. A team of experts manufacture filter systems that will quantitatively and qualitatively define specific spaceflight parameters. Another group adds the individual specialized compartments or cuvettes that actually house the fungal cells within the flight hardware. Others are responsible for insulation, temperature recorders, and other sensing devices. Still other specialists enter in testing and quality control. A carrying case or nonflight transporter is constructed to house the spaceflight hardware to stabilize temperatures and decrease vibrations for the trip from NASA Houston to the launch pad in Florida. An astronaut is trained to deploy the experiment in space and a 10 minute  $\pm$  5 second time slot is placed in the flight plan for MEED deployment in space.

New pharmaceuticals become available and are incorporated into a planned experiment. A graduate student obtains permission at a medical center to collect biological specimens from medical patients undergoing treatment for specific diseases that will be used in a bioassay test system. Another graduate student receives a haircut that provides human hair from a single source for utilization in a series of experiments covering a two year period. The necessary chemicals are ordered and specialized equipment reserved for proposed studies. Techniques in various experimentations and procedures are refined to apply more directly to a specific spaceflight study.

Suggestions, assistance, and experiments evolve from university and industrial laboratories. Countless additional preparations occur that follow a precise time schedule leading to the placement of selected fungal species of a predetermined age in the spaceflight hardware. Transporting the flight package to the launch pad, the spaceflight and deployment in space, splashdown, and return for hardware unloading and cell retrieval require precise timing and additional groups of specialized individuals working on the coordinated effort. That complex effort is focused on learning more

about the effects of space on biological systems. The discipline selected as the tool of study is mycology fortified with related studies in medicine, genetics, morphology, anatomy, enzymology, cytology, pharmacology, nutrition, and histology.

The coordinated as well as cooperative effort of many people, numerous disciplines, and diverse facilities presents one study of mycology in space. It is hoped that the effort in exomycology will be as meaningful as the many people have been in assisting the project. Attention is directed to the spaceflight hardware design and construction.

The Microbial Ecology Evaluation Device: The Apollo 16 mission to the surface of the moon was launched 16 April 1972 and landed a few days later in the highlands region of the moon. While the lunar exploration was underway by 2 of the 3 astronauts, Ken Mattingly remained in the Command Service Module (CSM) to perform many scientific experiments. These orbital experiments obtained data from the lunar surface including approximate chemical composition of surface materials, gravity variations, lunar magnetic fields, elevation features, and photography of many lunar features previously not photographed. Upon completion of the lunar surface activity, the Lunar Module (LM) lift off from the Descartes region of the moon was followed by rendezvous with the CSM. After transfer of lunar samples, film and equipment from the LM to the CSM, and placement of a few items no longer needed from the CSM to the LM, the separate spacecrafts were sealed and the LM was jettisoned toward the moon while the CSM began the transearth coast (Simmons, 1972; Mattingly, et al., 1972; Pippert, et al., 1972).

During the transearth Extra Vehicular Activity (EVA) of Apollo 16 on 25 April, the MEED flight assembly was removed from the stowage bag in the Command Module (CM) and deployed by Astronaut Ken Mattingly during the latter part of the EVA period 174,000 miles from earth. With the CM hatch secured in an open position, the TV camera was removed from the TV and Data Acquisition Camera Pole (Campole) and replaced by the MEED system. No inflight photos were made of the activities. Two trays housing cuvettes were exposed to the light radiations while a third tray remained in the dark during the 10 min + 7 sec deployment. Various cuvette types for the fungal ascospores, conidia and vegetative yeast cells included dry unvented, dry vented to space vacuum, and wet cuvettes with distilled water as the holding solution. Other cuvettes contained film chips, potassium ferroxilate solution as well as other measuring devices. Temperature indicators were distributed throughout the 3 cuvette trays for the recording of maximum temperatures obtained during the mission.

After exposure the MEED case was closed, reinserted in the stowage bag, and placed in the CM stowage compartment. No measurements were made in space except to align the MEED 90° to solar radiation. Recovery and air shipment of the MEED to the Lunar

Receiving Laboratory (LRL) immediately after splashdown was carried out in a temperature controlled carrying case (Anon. 1971 b). Cuvettes were unloaded from the MEED hardware at the LRL NASA Houston where they were preflight packaged. Fungal cell recovery followed for specific examination of the test systems.

The MEED flight hardware extremities totaled  $5.3 \times 5.3 \times 10.5$  inches. Total weight was 8.45 lbs with a stowage bag of 1.8 lbs. The flight hardware was composed of 3 trays of cuvettes. Each cuvette had a 0.05 ml volume capacity. Cuvettes housed the selected test systems. Thermal hardware requirements for the microbial cuvettes were maintained at  $20^{\circ} \pm 5^{\circ}$  C throughout the Apollo mission and during the 10 minute MEED deployment. Optical requirements obtained by a series of filters provided a maximum of 5 energy levels from  $10$  to  $10^5$  ergs per cuvette for the 10 minute exposure and a selection of peak intensities at 254, 280, and 300 nanometers (nm)  $\pm 3$  nm (Anon. 1971 a). Full light and dark flight control were additional test parameters. Other controls included cells housed in cuvettes in the laboratory during the Apollo 16 flight in addition to preflight and solar simulation studies.

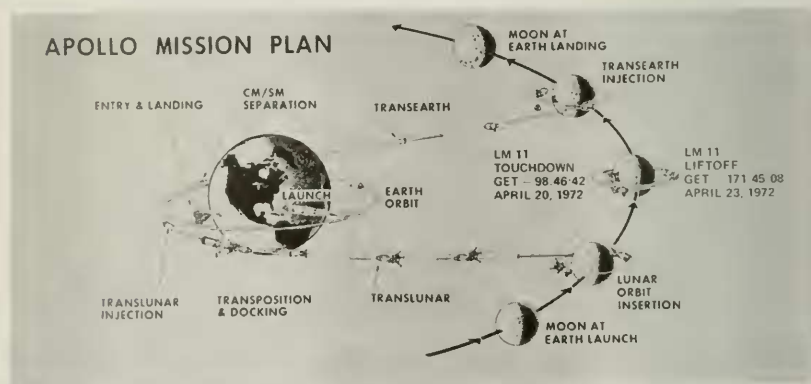


Figure 1. The Apollo 16 mission was the ninth manned Saturn V mission, the sixth lunar landing mission, manned by J. W. Young, T. K. Mattingly II and C. M. Duke. Command Module Pilot Mattingly deployed the MEED during the transearth Extra Vehicular Activity of the mission plan (Delco Electronics, Milwaukee).





Figure 2. Artist conception of the transearth Extra Vehicular Activity with one astronaut in the vicinity of the Service Module SIM bay preparing to remove film from one camera and the other astronaut at the Command Module Hatch where the MEED was attached to the same pole bracket on which the TV camera was previously fastened.

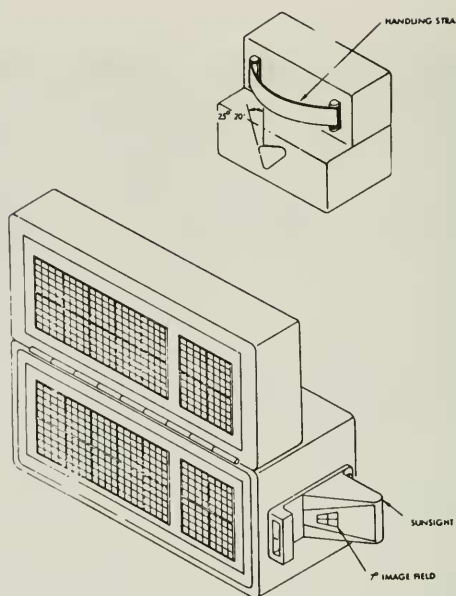


Figure 3. The MEED flight hardware illustrating the open deployment of two cuvette trays with one tray housed in the dark in the lower compartment. The sunsight and image field alignment is also shown that served as a visual check for the computerized spacecraft maneuver that allowed a  $90^{\circ}$  angle deployment toward the sun.

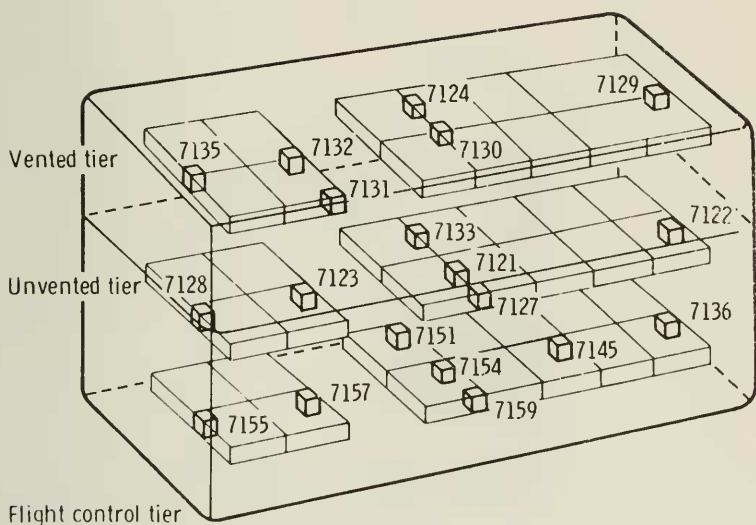


Figure 4. Arrangement of cuvettes within the MEED to measure high energy multicharged cosmic ray particle bombardment on the spaceflight hardware using cellulose nitrate, Lexan polycarbonate, nuclear emulsion, and silver chloride crystal nuclear track detectors (Benton and Henke, 1972). Additional space environmental measurements included cuvettes housing potassium ferrioxalate actinometry as a spaceflight ultraviolet irradiation dosimeter system (Parson, 1972).

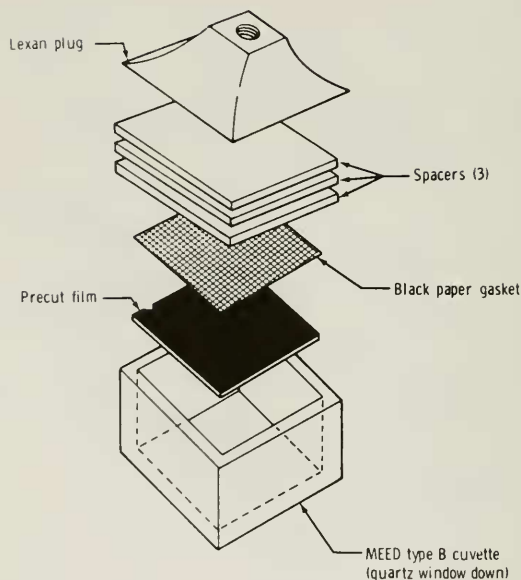


Figure 5. High resolution film was used in a few cuvettes housed within the MEED to measure solar ultraviolet irradiation at 254 nm between energy levels of 3 to 130 ergs to further evaluate irradianations in space (Long, 1972).

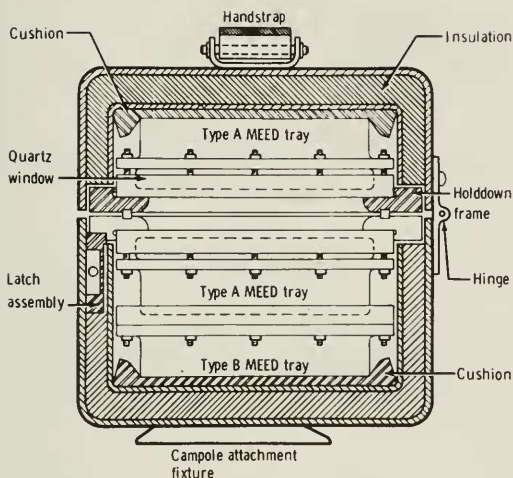


Figure 6. Interior end view of the MEED flight assembly. Temperature recorders were distributed throughout the 3 MEED trays to measure the high and low fluctuations within the MEED. Each recorder occupied a volume of 4 cuvettes and contained a bimetallic coil spring. A scribe was attached to the spring to record the maximum temperatures by scratching on a carbon glass surface (Taylor, 1970).



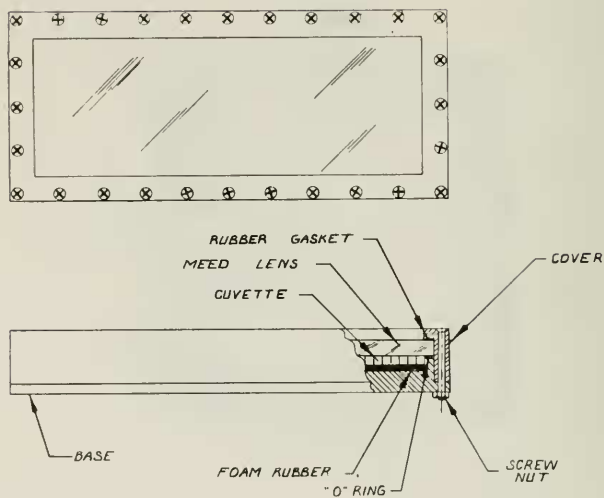


Figure 7. The MEED tray assembly shown in a preflight test model. The system was required to maintain a pressure of  $14.7 \pm 2$  psia throughout the spaceflight experiment. The burst pressure of the MEED was adequate to provide a high overall factor of safety. The MEED kept the biological sample temperatures at  $20^\circ \pm 5^\circ$  C (Taylor, 1970).

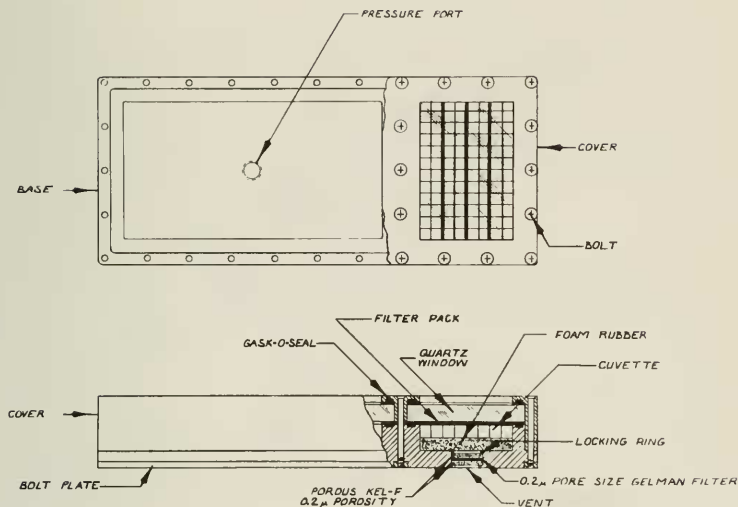


Figure 8. The MEED flight hardware provided approximately one fourth of its surface area as a vented chamber that held cuvettes vented to the space environment. About three fourths of the surface area held sealed cuvettes in sealed compartments. The MEED held mechanical integrity under shock loads of 78 g's for 25 milliseconds. The filter pack consisted of two filters each. Quartz bandpass interference filters provided peak wavelengths of 254, 280 or 300 nm while quartz neutral density filters regulated the total radiant energy between  $4 \times 10^1$  ergs/cm<sup>2</sup> to full sunlight penetration in space of  $8 \times 10^8$  ergs/cm<sup>2</sup>. One each of the two filter types controlled the total radiant energy and peak wavelength entering each cuvette chamber (Taylor, 1970).

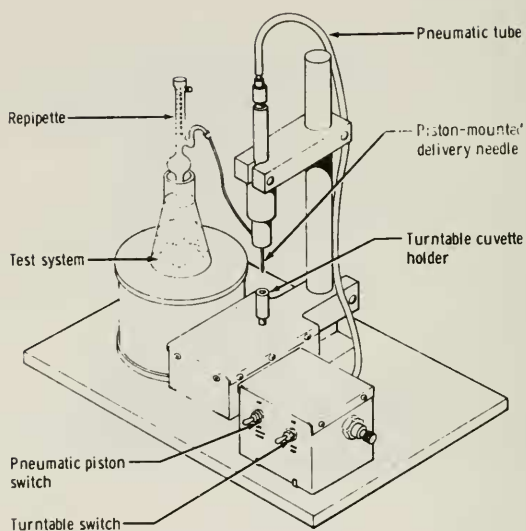


Figure 9. Type A cuvettes held yeast cells, ascospores or conidia in distilled water. The cuvettes were designed to contain 50 microliters of the cell suspension. The wet cuvette loader consisted of an electric turntable cuvette holder and a piston mounted needle equipped with a fill hose connected to a repipette that was equipped with a lambda dial (Carmichael and Ellis, 1972).

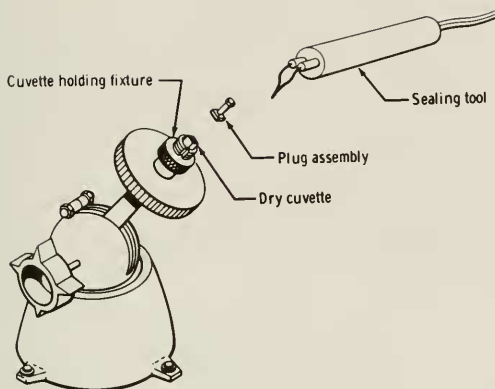


Figure 10. Fungal cells were housed dry in unvented cuvettes (type B) or in cuvettes vented to the space environment (type c). A known cell concentration of a fungal species was filtered through sterile Millipore filter paper that had an average pore diameter of 0.45 micrometers. A thin layer of cells about one cell thick was deposited on the filter paper. A sterile square punch cut filter paper squares the size of the interior of the cuvette. At the dry cuvette loading station the filter paper squares were placed in the cuvette so that the dry cell layer was against the inside of the cuvette quartz window. Two sterile spacers and a sterile plug assembly consisting of a screw placed in a plastic pyramid held the Millipore filter paper securely in the cuvette (Carmichael and Ellis, 1972).

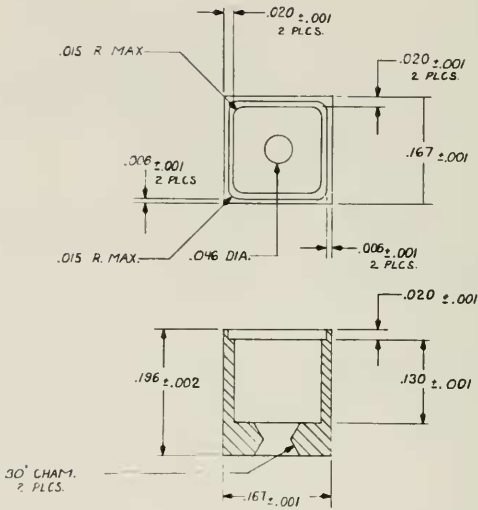


Figure 11. A plexiglas type A cuvette with a quartz window was developed to house the fungal cells in a distilled water suspension. The window was bonded with epoxy cement and then the cuvette was oven dried. The hour glass shaped filling hole provided a secure seal when filled with wax (Taylor, 1970).



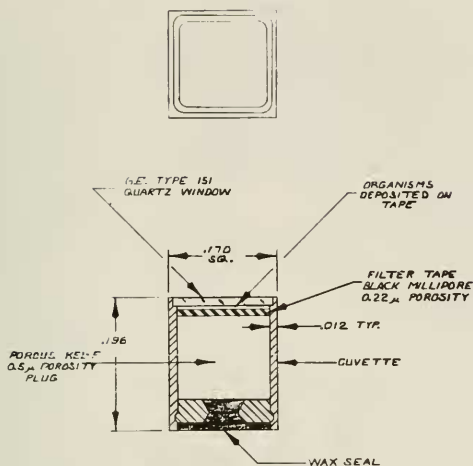


Figure 12. An early design of a type B cuvette that housed fungal cells dry, unvented to space. Material on which the cells were deposited was changed, including the porosity size of the filter paper. Early cuvette spacer components also varied with the spaceflight cuvette pyramid assembly. The wax seal provided this cuvette type an environment unvented to space vacuum. Type C cuvettes were vented to space vacuum when the plug assembly screw was removed without filling the remaining hole with wax. Type C cuvettes were housed in MEED spaceflight hardware units vented to space (Taylor, 1970).

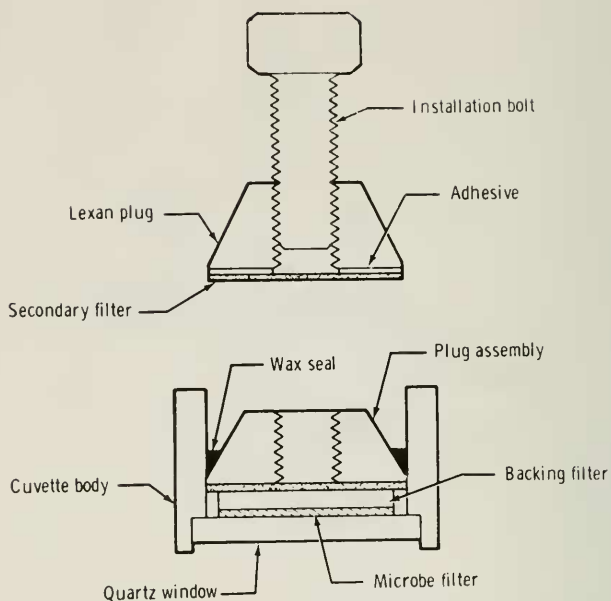


Figure 13. The final spaceflight dry cuvettes type B and C had the same external body dimensions and quartz window as the wet cuvettes (Chassay and Taylor, 1972).

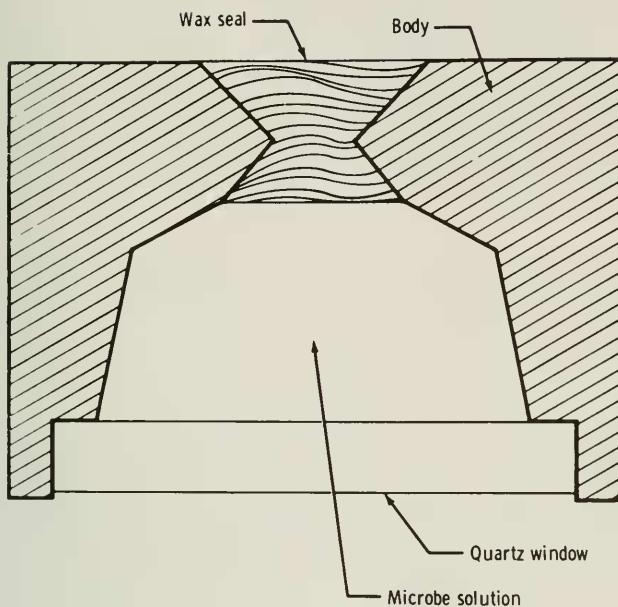


Figure 14. The final wet type A cuvettes were constructed of Lexan tinted black to prevent light scatter. A  $0.05 \text{ cm}^3$  volume was maintained while a  $7^\circ$  internal slope was provided to reduce the possible shadowing of fungal cells within the chamber (Chassay and Taylor, 1972).

The MEED Mycology Studies: Several postflight studies have been conducted to date to evaluate changes at the cellular level incurred in space with the four fungal test species. The species were selected for spaceflight study from preflight tests on numerous fungal species representing most all major classes of fungi (Volz, 1974). Criteria for their selection included the ability to survive constraints of the planned spaceflight hardware, the usefulness of the species for identifying change in the microorganisms incurred in space, previous space related research in mycology related to the proposed studies, and ease of handling the organisms. The role of fungi in space related research previous to and concurrent with manned space exploration was investigated to assist in the selection of species for the Apollo MEED project (Dublin and Volz, 1973).

The four spaceflight fungal species serve as good test organisms in identifying changes incurred at the cellular level by environmental stresses identified in the spaceflight experiment design. Survival, death and phenotype counts yielded variation in the 4 fungal species housed in controls and the flight exposed cuvettes. Fungi exposed to specific spaceflight conditions demonstrated variable survival rates and phenotype counts. In general, phenotype counts for flight cuvettes and survival rates for control cuvettes were each higher in comparison to the remaining cuvettes (Volz, et al., 1974). Hyphal growth dynamics of Trichophyton terrestre and Chaetomium globosum spaceflight phenotypes such as colony perimeter growth density, protoplasmic leakage of hyphal apices damaged by ultraviolet light irradiation, abnormal growth at the hyphal apex, forked hyphal branches, irregular hyphal walls, and additional morphological changes were attributed to spaceflight exposure (Volz and Dublin, 1973). The meiotic and mitotic configuration of Chaetomium globosum wild type and nuclear behavior in Trichophyton terrestre spaceflight parent strains were investigated (Hsu et al., 1973 a, 1973 b, 1974, Hsu and Volz, 1975 a).

Phenotypic variants of the two spaceflight filamentous fungi and of the two yeasts, Rhodotorula rubra and Saccharomyces cerevisiae, were exposed to pooled salivary samples of healthy individuals, and saliva from patients receiving radiation treatment for malignancies, protracted corticosteroid regimes for renal complications, and insulin therapy for diabetes mellitus. Significant variations occurred in fungal growth rates according to phenotype association with specific salivary samples (Dublin, et al., 1974). Host compromised saliva was less able to reduce growth rates of test fungi compared with normal saliva. As spaceflight environmental stress increased in cells housed in the Apollo 16 MEED, fungal growth decreased in the presence of salivary peroxidase activity. In another study it was learned that each layer of the Apollo and Skylab Extravehicular Modular Unit space suit either directly supported fungal growth or, since it was porous, allowed

the diffusion of available nutrients to support fungal growth (Volz and Jerger, 1973).

The penetration and progressive destruction of human hair by strains of T. terrestre was studied by electron microscopy (Hsu and Volz, 1975 b). Nuclear weight determinations and reassociation studies were performed on one phenotype each of C. globosum and T. terrestre. Genome size of the phenotypes in comparison to the parent strains exhibited a slight increase in both nucleotide pairs per haploid nucleus (Jerger and Volz, 1975). A space flown phenotype of T. terrestre compared with the wild type differed in phospholipid content. The studies concluded that exposure of wild type T. terrestre to specific spaceflight parameters resulted in a phenotype whose whole cell phospholipid contents varied from that of the wild type (Sawyer, et al., 1975).

Additional studies are currently under way including the evaluation of data obtained in other postflight investigations on the spaceflight fungal phenotypes. Experiments on the phenotypes were designed to determine what measurable and identifiable changes did occur to the fungal cells in space. Two separate evaluations were designed for nutritional studies of phenotypes. A study of growth rates and changes of fungal phenotypes inoculated on agar containing various carbon and nitrogen sources, and a study on the use of minimal media for analysis of vitamin and amino acid requirements are underway. The disk method was selected to test several anti-fungal drugs on flight phenotypes. In another study an experiment was designed to study histopathological variations of induced lesions in mice and hamsters caused by injected cells from selected phenotypes. A spectrophotometric acid dichromate method for the determination of ethyl alcohol was utilized in one of the spaceflight studies with flight phenotypes capable of producing alcohol.

Investigations are continuing for the identification of possible additional phospholipids as well as variation in lipid quantity in wild type and spaceflight phenotypes. Postflight studies of the Apollo 16 MEED mycology include comparative investigations on the wild type and select spaceflight phenotypes of four fungal species for the purpose of characterizing the parent strain and identifying changes in the phenotypes that incurred in space.

Voice Transcript of the MEED: Discussion between the Apollo 16 Command Module and Control Center at NASA Houston, and between the Command Module Pilot and Lunar Module Pilot describes the activity involved in deploying the MEED. In addition to the MEED, discussion concerned other activities of the Extra Vehicular Activity during the MEED deployment in space and reentry into the Command Module by the astronauts for the return to earth.



GMT Launch

(month, day, hour, minute, second)

04 16 17 54 00

Actual Elapsed Time

(day, hour, minute, second)

Transcript

09 01 52 48 CMP Wait a minute, John. Let me put this back up.  
Watch your head there. Big thing.

09 01 53 08 CMP Okay. We have the TV power off, did you say? Okay.  
And the camera's back in place. All right. Okay.  
We've been doing that. You might check them. Be  
sure you can.

09 01 53 21 CDR Okay, Houston. You read me okay on the CDR'S loop?

09 01 53 25 CC Houston's reading you 5 by 5, John.

09 01 53 31 CDR Okay.

09 01 53 43 CMP Pressure alarm is coming on. I have the warning  
tone. It's going back off, and the tone is off.

09 01 53 59 CMP You can call verb 49, and it will already be  
loaded. Yeah. You've got to pro out of this.

09 01 54 26 CMP It may be out of attitude, but - Okay. Take 2  
pro's to go to the MEED attitude. Okay?

09 01 54 52 CMP Okay, the repress O2 is about 865.

09 01 55 10 CMP No, that acts as a supplement to the Surge Tank.  
All right.

09 01 55 32 CMP Okay. Let me check noun 351. Okay. The Repress  
Valve is off. That's verified. That's verified.  
Can you get this in your...\*

09 01 56 59 CMP You want me to stuff it in my TSB?

09 01 57 01 CMP I'll see. I'll see.

09 01 57 02 LMP Yeah.

09 01 57 03 CMP Okay.

09 01 57 04 LMP I'll tell you what, I'm going to put it up here,  
I don't want to lose this one.

09 01 57 29 CMP Okay, the Flight Plan is stowed in R3.

09 01 58 12 CMP Okay. I've got it.

09 01 58 30 CMP Yes, sir. And I have the valve in the open posi-  
tion, and would you verify that that's open.  
Counterclockwise - No, what does it say on the  
arrow? Okay. And it's locked.

09 01 59 20 CMP Okay. Wrist tether's out, stowed. Yep. My hoses  
are disconnected and stowed. Yes, sir. Inter-  
connect is in. Suit flow is off, the intercon-  
nect is in. It's locked on two sides, and stowed  
on the strut. I have it. Okay. I've got it in  
location. Okay. It's installed and locked. Nope.  
That's mine. It's off. Yes. Okay.

09 02 01 31 CMP Okay, I've got the adapter plate on.

09 02 02 29 CMP Yes, sir. And I've disconnected the OPS hose.  
They're snapped. They're installed.

09 02 03 25 CMP Just a little bit easier.

09 02 04 57 CMP Am I getting that twisted? I want to go over the  
umbilical. That's it, thank you. Thank you.

Okay. The OPS is installed, the gas connector is installed, and it's locked. Yes, sir. If you can. May have to disconnect this thing to get it down there. All right, thank you. It'll stay. Yeah, that's nice. Oh, I'm sorry, I didn't hear you. Okay. O<sub>2</sub> flow is coming on.

09 02 05 02 CMP Mark. I have flow..Yes, sir. But will you watch cabin pressure for me? Want me to read those while you guys do the integrity check? Okay. Let me get up here. You want me to read those things?

09 02 06 02 CMP Hey, where's the other? Here's your helmet, where's mine, laid it down? Okay. I'll get it out for y'all. Here's yours, John. Those are your gloves, Charlie, okay. Okay, my gloves should be down there to your right somewhere, I think. Yeah, get them out of the way. Okay. All right, thank you.

09 03 06 32 CMP Add right, thank you, Charlie. Now, I'll put my feet in here, and we'll take a look at the old mapper. Okay, while I'm standing on top of the DAC camera, the V-over-h sensor looks perfectly clean. There's nothing on the sensor. I see no evidence of contamination on the sensor, either the light meter or the V over h. The barrel is clean, all the decks and surfaces of the pan camera installation are clean.

09 03 07 13 CC Very good, Ken.

09 03 07 28 CMP Okay, here comes the mapping camera cover, hard cover. The soft cover. Okay, that'll be next. Yeah, that's my wrist tether.

09 03 08 12 CMP Ready?

09 03 08 26 CMP Okay, I'm putting the tether on now, John.

09 03 09 05 CMP Oh, I'm having trouble with this hook. If I can get it on, I can get it locked.

09 03 09 48 CMP Stand by.

09 03 10 41 CMP Oh, yeah. I just can't get the darned insulation out of the way. It's a little stiff.

09 03 10 56 CMP Okay, it's on.

09 03 11 49 CMP Okay, why don't you wait until I get to the hatch?

09 03 12 12 CMP I see them.

09 03 12 39 CMP If you get it hooked on, you can pull the tether off my hand there, Charlie.

09 03 12 53 CMP No, sir. Okay, how we doing on umbilical now? How we doing on umbilical? You got most of it inside? Okay. Go ahead.

09 03 13 21 CMP Yes, after Charlie gets in.

09 03 14 07 CMP Hey, let's go on back to the - Let's see - okay. Yeah, yeah. Let me turn around here and get my feet in.

09 03 14 40 CMP Okay, wait a minute. Got to - Let me see if I can find a place to put my feet here. Is that a safe

place for my right foot? Okay.

- 09 03 15 07 CMP You have anything on the TV?
- 09 03 15 12 CC Not right now. Yeah, we got something there.
- 09 03 15 20 CMP Yeah, I'm not very steady here.
- 09 03 15 24 CC Looks like the old Moon.
- 09 03 15 28 CMP That's her, babe. Right off the nose.
- 09 03 15 35 CMP Okay, that's all for today on that (TV camera off).
- 09 03 15 48 CMP Okay, I'm going to have to pull myself in. Let me send this thing in to Charlie. All righty.
- 09 03 16 23 CMP Okay.
- 09 03 16 24 LMP Go ahead.
- 09 03 16 25 CMP Let me get my umbilical down here. Yes, sir. Okay, Houston, we're maneuvering to the MEED attitude.
- 09 03 16 43 CC Roger.
- 09 03 16 50 CMP Don't move my feet. I'll lift.
- 09 03 17 11 CMP I got the pole. Okay.
- 09 03 17 24 CMP Okay, let me pull this rail down to hold on to and we'll play ride'em cowboy.
- 09 03 17 45 CMP Is that enough out of the way, Charlie? Okay.
- 09 03 18 06 CMP Easy. How's that?
- 09 03 18 40 CMP Okay. No, it's in the two-bar. No, Charlie's going to unstow it. Okay. Oops! How about if I slide over here? Okay. All right? Let me - No, I got it here, I think. From here you can't either? Okay, all right, okay. I got to come in to turn around. Hold this pole until I get out. If you let John hold it, then it'll be easier.
- 09 03 19 52 CMP Okay. How's that?
- 09 03 20 10 CMP And, right now, I've got the Earth peeking over the side of the fuselage, just a little crescent. Okay, coming in.
- 09 03 20 40 CMP Fine. Yeah, okay, I got that. And hold.
- 09 03 21 10 CMP Okay, Houston, we've reached the MEED attitude.
- 09 03 21 16 CC Roger.
- 09 03 21 19 CMP Wait a minute. Okay, it's locked. Of course, we got it. Okay, out with the MEED.
- 09 03 21 54 CMP Seven. I found a sight here. Wait a minute.
- 09 03 22 20 CMP I got to rotate this another few degrees. You got both my feet there? Okay.
- 09 03 22 43 CMP Okay, all right, let go of my feet there, get up here to attitude - there's my foot there - I don't have to go outside, I don't think. Let's see, Charlie, you're going to have to, let me see.
- 09 03 23 26 CMP All right, just a second. Oh, that's just what we didn't think about. That Velcro strip lays right in front. Yep. Hang on, I've got my scissors right here. I'll be right with you. Yes, sir. Okay, what we do need to do is to pitch up, minimum impulse. Oh, you've got to go about 3 degrees.

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09 03 24 50 CMP Put in - input yet? Okay, go - pitch down then. Yeah. Okay, up should be in the right direction on this thing. I said up the first time and that looked like it went the wrong way. You need to go up about 3 degrees.

09 03 25 25 CMP I can't tell that you're moving. Has the attitude changed? Yeah, yeah, and that's moving now. Moving in the right direction. Let it ride at the slow rate for about another minute.

09 03 26 19 CMP Okay, John we got another 30 seconds to drift and we'll be there.

09 03 27 16 CMP Okay. Why don't you go to auto?

09 03 27 22 CMP Okay, are you ready?

09 03 27 42 CMP Stand by.

09 03 28 01 CMP Hey, can you hold my feet?

09 03 28 19 CMP There it is (MEED deployed).

09 03 28 22 CMP Okay, pull me in. I'll pull myself in.

09 03 28 31 CC Is the MEED open now, Ken?

09 03 28 36 CMP Yes, sir.

09 03 28 39 CC Okay, I didn't get your mark.

09 03 28 40 CMP It's been open 15 or 20 now. Sorry.

09 03 28 42 CDR Yeah, it's on 22 seconds now.

09 03 29 38 CMP What kind of pressure do you have now?

09 03 29 49 CMP How about our suit gauges?

09 03 30 15 CMP Okay.

09 03 30 21 CMP I'm very comfortable.

09 03 30 29 CMP 3.85. Like a champ.

09 03 30 38 CC John, could you give us a cuff gauge reading?

09 03 30 44 CMP Okay, I got 3.85, Hank.

09 03 30 58 CC Roger. Could we get one from John and Charlie?

09 03 31 00 CMP Do you want all of them or just mine? Okay, say again what you had, John. John has 3.55.

09 03 31 08 CC John has 3.55. Roger.

09 03 31 11 CMP Charlie has 3.95.

09 03 31 13 CC 3.95.

09 03 31 28 CMP Probably getting some off the bulkheads, too, drying this place out.

09 03 31 40 CMP Hey, how's the time coming?

09 03 31 45 CMP Okay, it's sure not.

09 03 31 57 CMP Houston, you are now witnessing one of the longest 10 minute periods in history.

09 03 32 02 CC Roger.

09 03 32 51 CMP Okay.

09 03 32 56 CMP Henry, was there anything else you wanted to know about the SIM?

09 03 33 02 CC Roger. When you were around the mapping camera, did you happen to notice the condition of the cable that lays between it and the bulkhead there?

09 03 33 12 CMP I couldn't see down in there. There's too many shadows.

09 03 33 15 CC Roger, copy. And on the stellar camera door, how far out was it?

09 03 33 22 CMP Oh, I'd say the last folding lip is up against the handrail. Well, just about that far.

09 03 33 32 CC Roger.

09 03 33 37 CMP All right, thank you. Oh, I'm just fine. I got nothing to do but just loop my finger around this thing.

09 03 35 21 CMP No wonder that was such a long time. Hank, we got another one of those event timers that's timed to some base other than universal time.

09 03 35 33 CC Say again.

09 03 35 34 CMP But don't worry about the MEED, we got a watch on it.

09 03 35 37 CC Okay, I'm timing you down here, too.

09 03 35 41 CMP Okay, we got regular watches on it, so it's okay. Why don't you check us at 8 minutes, Hank?

09 03 35 50 CC Will do.

09 03 36 17 CC Coming up on 8 minutes.

09 03 36 21 CC Mark.

09 03 36 26 CMP Okay, thank you, Hank. We're right with you.

09 03 36 48 CMP You get a good look at the Earth, Charlie?

09 03 37 05 CMP I'm really surprised I don't see any stars.

09 03 37 21 CMP (Laughter) What time is it? Okay, 9 minutes.

09 03 37 51 CC Got about 30 seconds, Ken.

09 03 37 54 CMP Okay, I'm on my way to the experiment. Charlie, can you hold my feet there? And would somebody give me a call at 10?

09 03 38 11 CMP Man, that sunsight's right on.

09 03 38 12 CC Ten seconds.

09 03 38 14 CMP Okay. We're counting down the last ten.

09 03 38 22 CMP Closed.

09 03 38 24 CC Okay, make sure the MEED is closed and locked, Ken.

09 03 38 29 CMP It's closed, I'm working on the lock.

09 03 38 42 CMP Charlie, can you hold my feet real good there? Hold both of them. Okay.

09 03 39 17 CMP Well, I didn't get it locked. Yeah, I'm working on that, John. I got to compress the seal. I'm trying to get some leverage on it.

09 03 39 50 CMP Wait a minute.

09 03 40 10 CMP Well. No.

09 03 41 01 CC Ken, you having any luck with that lock yet?

09 03 41 03 CMP Not yet.

09 03 41 11 CC Okay, that goes clockwise and then closes, and then counterclockwise.

09 03 41 18 CMP Yes, sir, I've got the sequence. It's the lock I don't have.

09 03 41 25 CDR How about if we bring it in and tape it closed?

09 03 41 28 CMP I'm gonna do that in just a second, if I don't get it on this try. Well. Hey, there we go, I



think. Let me try that now.

09 03 41 52 CMP I feel it coming.

09 03 42 13 CMP Well, I'm going to have to let it have a little extra UV.

09 03 42 28 CMP Because I can't hold it shut and bring it in. Charlie, you got my foot?

09 03 42 42 CC Ken, do you intend to use the TV any more?

09 03 42 47 CMP No, sir. Okay, I've got to get that thing closed here, at least out of the UV. Okay, I've got it. It was - Hank, it was open for about 3 seconds.

09 03 43 08 CC Roger.

09 03 42 27 CMP You got it?

09 03 43 34 CMP All right.

09 03 43 42 CMP Let me get my hand out of here, that's what's holding me up; now you can pull it in.

09 03 43 55 CMP Wrap a piece of that tether around it until we get the cabin pressurized. You got it? Okay.

09 03 44 16 CMP You can probably stick the whole thing under there.

09 03 44 27 CMP Take your time and get it all cleaned up. All righty.

09 03 44 56 CMP I see a piece of tether coming up here, is that the MEED? Okay. Don't disconnect the lanyard.

09 03 45 15 CMP Okay. I'll turn around and start in. (Laughter) Rub-a-dub-dub. Okay, you got my umbilical in sight?

09 03 45 40 CMP Okay. Let me get my - I've got to get - Something's under my foot there. Okay, I've got to get my foot low in order to get in. Want me to go back out? Hey, okay, swing. Oh, not quite. Got to get this thing up where I can see something.

09 03 46 42 LMP Look at that!

09 03 46 50 CMP John, you sure have a lousy LEVA. It's closed and the hatch is clear. Just a second. Okay. All right. Before I take it any further, let me try some of those latch seals. You're right. Can you see the latch seals? I can't see the top. Can you see the top, John? I just want to make sure I don't have something stuck - a lanyard stuck in there somewhere. Okay? Hey, the handle - the indicator looks latched. Yes, sir.

09 03 48 35 CC Okay, Ken. Before you pressurize the cabin, we'd like for you to verify that the switch on the TV is in standby, and the the S-band aux TV is off.

09 03 48 48 CMP Okay. What's the next step on the latches, here? I think you read one I did miss. It's latched. Okay, let me, I can get that TV switch. Hey - Okay. That's a big help. The switch is off. That's affirmative. Oh, I can't find that. Wasn't on the checklist. Yes, you do. Right up there. I'm trying to get the visor up so I can see. (Laughter) No, I'm going to use this hatch right

here. If I can read through this thing. It's right there. Okay. Dump valve coming close. Okay, the pressure equalization valve is closed. Okay, watch this. I'll just sort of hit it once and see how it works.

09 03 51 39 CDR Okay. Houston, can you call us at a cabin pressure of 1?

09 03 51 42 CC Will do.

09 03 51 42 CMP I'll get it.

09 03 51 44 LMP Say again.

09 03 51 45 CC Roger. We'll give you a call at 1 psi.

09 03 51 53 CDR Okay. We're repressuring now. Okay.

09 03 52 07 CMP I show not quite 1 on the gauge. Okay, Henry. We're showing almost 1 on our gauge, and we're letting it - watch for a minute or so.

09 03 52 27 CC Roger. We're showing 0.5 down here.

09 03 52 32 CMP Okay.

09 03 52 34 CC 0.6 now.

09 03 52 35 CMP Cabin check, isn't it?

09 03 52 42 CC That's affirmative.

09 03 52 43 CMP He says it's 0.6 Okay. And what time - we have a minute here? Three minutes? Thirty seconds. Okay. Looks closed to me. Okay, Houston, we're content with the check.

09 03 53 23 CC Looks pretty good from down here.

09 03 53 24 CDR Repress.

09 03 53 29 CMP Dump open?

09 03 53 40 CMP I am. Nigh unto there. Just about.

09 03 54 11 CMP Just a second.

09 03 54 24 CMP Cabin pressure I show 2.

09 03 54 31 CC Roger. We're showing 1.9.

09 03 54 36 CMP Okay.

09 03 54 37 CC 2.0 now.

09 03 54 41 CMP Okay, it's close.

09 03 55 25 CMP That's 1265.

09 03 56 23 CMP All right, sir. We've got about 2 - 4, it looks like. Yeah. Sure is, 85. It's 5 inches wide.

09 03 58 06 CMP Charlie? Doesn't seem like it, does it? (Laughter) I guess that depends on your point of view, huh?

09 03 58 32 CMP And this umbilical isn't putting out an awful lot compared to this big volume.

09 03 58 39 CDR And the umbilical is bringing it up slowly, Houston, but it looks normal.

09 03 58 45 CC Ken, is it convenient for somebody to start a verb 49 to the thermal attitude?

09 03 58 53 CMP Yes, sir. If you can read it to us. We don't have any books out or anything.

09 03 58 59 CC Okay, your noun 22 is 175, 283, 340. And we want to change the DAP first. Verb 48 will be - And if you can get to it, we enable all the jets.

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09 03 59 31 CMP You want me to move, John? Oh, Okay. What do you want on the DAP, Houston?

09 03 59 38 CC Okay, after enabling all jets, we want 11101, and then all 1's.

09 04 00 09 CMP Okay, leave the B/C roll jets off. Just leave enable coupled. Yes, sir. Just turn the A/C roll on. Okay, and all of the pitch and yaw. Push the three, maybe, or four, maybe, circuit breakers back in. Okay, you're in business. You have the auto coiled?

09 04 01 18 CDR Hank, say again those numbers for the attitude?

09 04 01 20 CC Okay, R-1 is 17500, plus 28300, plus 34000. And would you check jet Charlie 1, on.

09 04 02 03 CMP Do they want it on or off? Well, I don't think we've got quite that yet.

09 04 02 35 CDR Hey, Houston, I don't know what that problem we had with the glycol evap temp was. But there was a lot of ice crystals coming off from that side of the cockpit, and maybe it was affecting some of the temperatures over underneath that region, which are probably covered with condensate.

09 04 02 57 CMP Got to roll over so John can get to my valve.

09 04 03 02 CC Roger. That may have been it, John.

09 04 03 09 CMP Look at that. I did it. (Laughter) Boy! When I get off VOX, I'll tell you. Okay. Why don't you do something to my suit so I can get depressurized, there?

09 04 03 36 CC Roger, Ken. We're showing you at 3 psi now.

09 04 03 40 CMP Okay. Thank you. Read the card there. Well, I think we're going to pump the cabin up with it, Charlie. Just read the - Yep.

09 04 04 00 CMP (Laughter) You got it! They didn't make the string quite long enough. Okay? Where is it? (Laughter) Well, we'll find it if it comes. I don't want to let it come lose on the panel. Can you reach the - You got it? Okay, I'm gonna open it. Okay? All set? Here we go. I've gotta open the purge valve. I can reach the purge valve.

09 04 05 27 CMP Yeah. Why don't you punch it off, so you - it's under your card, there.

09 04 05 46 CMP Five and a half. Might as well go first class. Might as well. We want to empty it before entry.

09 04 05 58 CC 16, could we have auto on the high gain?

09 04 06 01 CMP (Laughter) In a minute. Can you reach it? Okay. Good thing you can reach it. I think that's where my OPS is.

09 04 07 01 CMP Okay, how's the cabin? Maybe I won't have to turn this thing off. Is it flowing, Charlie? Cabin regs are off.

09 04 07 17 CC Ken, we're showing 5.0 down here.

09 04 07 22 CMP Okay, thank you.

09 04 07 37 CMP I'll buy that.  
09 04 08 23 CC Ken, would you shut the OPS off? We show 5.5.  
09 04 08 28 CMP Okay. Is there anything wrong with taking it a little higher?  
09 04 08 37 CC You can take it on up to about 5.7, 5.8, Ken.  
09 04 08 42 CMP Okay, if you don't mind.  
09 04 09 19 CC We're showing you 5.8 now, Ken.  
09 04 09 24 CMP Okay, it's off. Okay, I'm gonna pop the purge valve.  
09 04 10 01 CMP Yes, sir.  
09 04 10 32 CC Ken, did you ever get the MEED locked?  
09 04 10 36 CMP Yes, sir.  
09 04 10 38 CC Okay. Verify it was locked.  
09 04 10 40 CMP It probably got another 5 seconds of exposure.  
09 04 10 43 CC Okay, real good.  
09 04 10 44 CMP Got another 5 seconds of exposure (Total 10 minutes plus 7 seconds), not all of which was on indirect UV. But as soon as we got it in the cockpit where a couple guys could get at it, it was locked.  
09 04 10 57 CC Good show. OMNI Delta, 16.  
09 04 11 07 CMP Can you get OMNI Delta?  
09 04 11 26 CMP I don't know. Hey, why don't you hold tight there. Okay. That'll do it. You've got it.  
09 04 13 50 CC 16, can one of you see the battery compartment reading now?  
09 04 14 00 CDR It's 2.0, Hank.  
09 04 14 01 CC Roger, 2.0.  
09 04 21 25 CC 16, Houston. When you get a chance - no rush - we'd like to switch over to B/D roll.  
09 04 24 11 CC Apollo 16, Houston.  
09 04 24 16 CDR Go ahead. Over.

Transcript and flight plan legend: CC, Control Center, Houston; CDR, Commander; CMP, Command Module Pilot; CST, Central Standard Time; DAC, Data Acquisition Camera; DAP, Digital Auto Pilot; EVA, Extra Vehicular Activity; GMT, Greenwich Mean Time; HGA, High Gain Antenna; LEVA, Lunar Extravehicular Visor Assembly; MEED, Microbial Ecology Evaluation Device; MNVR, Maneuver; MSFN, Manned Spaceflight Network; OMNI, Omnidirectional Antenna; OPS, Oxygen Purge System; P, Pitch; PAN, Panoramic; SIM, Scientific Instrument Module; TEC, Transearth Coast; TSB, Temporary Stowage Bay; V, Velocity; VOX, Voice Keying; Y, Yaw.

FLIGHT PLAN		NOTES
1354 CST		
242:00	<u>EVA OPERATIONS</u>	SIM EXP STATUS
(10101)	CMP EGRESS	(*0000)
(10011)		(00000)
:10	INSTALL TV/DAC, ADJUST	
:20	RETRIEVE PAN CAMERA CASSETTE	
242:30	REST	
	RETRIEVE MAPPING CAMERA CASSETTE	
	REST	
:40	REMOVE TV/DAC & INGRESS	
	V49 MNVR TO MEED ATT (242:44)	
	(058,054,037) HGA P -14, Y <u>226</u>	
	DEPLOY MEED ON POLE	
:50	ACTIVATE EXP, GIVE MARK	
243:00	DEACTIVATE EXP, GIVE MARK	
	REMOVE MEED AND POLE	

Figure 15. Time segment in the Apollo 16 Flight Plan for the MEED.

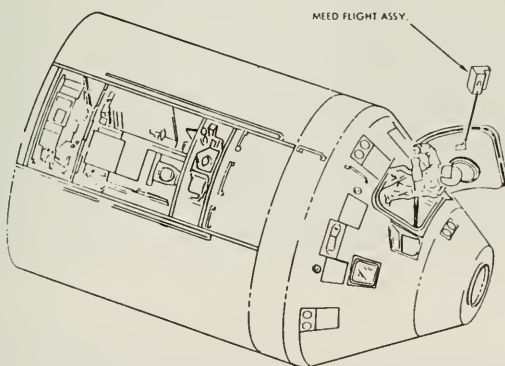


Figure 16. The MEED flight hardware deployed during the EVA.



Figure 17. Representatives of commemorative envelope cachets machine and hand canceled on April 25, 1972 marking the date and time of the Transearth Extravehicular Activity and the Microbial Ecology Evaluation Device mycology experiments deployment.



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